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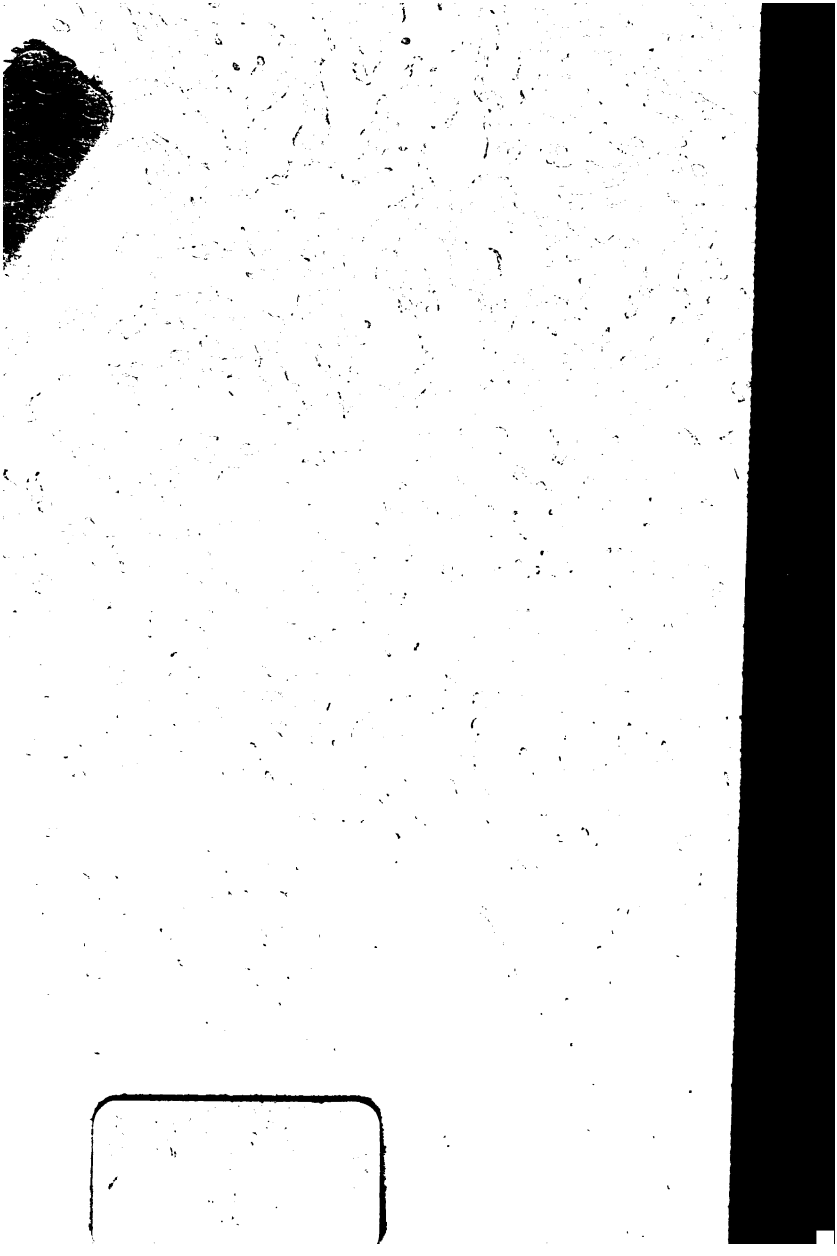

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USE AND CARE

OF THE

MICROSCOPE

BY

EDWARD BAUSCH

EXTRACTS FROM

MANIPULATION OF THE MICROSCOPE

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USE AND CARE OF THE MICROSCOPE.

Extracts from "Manipulation of the Microscope."

How to Set Up the Instrument. Draw the instrument from the case by grasping the base and pillar; free from dust with a large camel's hair brush, 1 inch or 1 1-2 inch, or by wiping carefully with chamois skin, or old linen. Place the instrument on the work-table, which should be of such height that observations can be made with the utmost possible comfort without straining the neck, or compressing the chest. Bear in mind always to sit as upright as possible.

If the instrument is used in the upright position, place the base close to the edge of the table; if inclined, it may set farther in. Rest the arms, as much as the height of the instrument will permit, upon the table.

Bring the tube to the standard length for which the objectives are corrected. To do this grasp the milled edge of the draw-tube and give it a spiral motion while holding the main tube with the other hand. There is one objection, however, that in any but cloth-lined

sheaths the polished tube will soon be scratched, especially if not kept very clean. In stands without the graduated tube, a mark or ring is or should be

Correct position at the microscope.

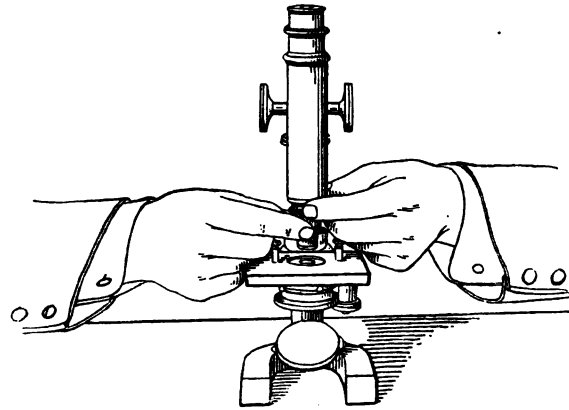
provided on it, which should be co-incident with the upper end of the main tube. Where graduated tube

is provided, bring the proper figure, either 216 or 160, in line with the upper end of the main tube in accordance with the tube length for which the objectives are corrected.

Attach low power eyepiece.
Attach low power objective.
Place object on stage.
Illuminate object.
Focus on object.

To Attach Eyepiece. The exterior surfaces of the eye-lens and field-lens, being exposed, are apt to become dusty, and *should always be carefully cleaned before using.* If there are two or more eyepieces, always use the lowest power first. Eyepieces should be so loosely fitted that they will drop into the tube as far as the collar *by their own weight.* They do this slowly when the objective is attached, as an air-tight compartment is formed and the air to the extent of the dimensions of the eyepiece must first be expelled from the tube. This displacement may, however, be hastened by gently pushing the eyepiece downward, but not to such an extent as to push in the draw-tube, or force down the coarse adjustment. In fact care must be used in applying the eyepiece, or sliding the draw-tube, as the focus may be disturbed, or the objective forced against the object and thus destroy it.

To Attach Objective. Using a low-power objective, remove from its box and see that its front lens is clean; elevate the tube of the stand by means of the coarse adjustment so that the nose-piece shall be at least two inches from the stage.

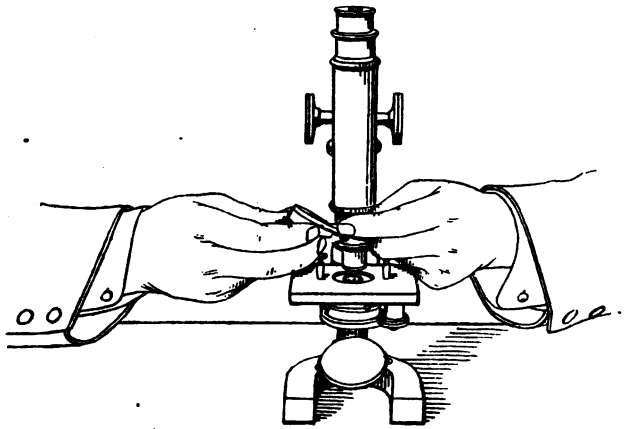


Proper manner of holding objective when attaching it to tube.

Grasp the upper knurled edge of the objective between thumb and forefinger of the left hand; bring the screw in contact with the screw of the nose-piece, and, keeping the objective in line with the tube and gently pressing upward, revolve the objective with the thumb and forefinger of the right hand by the lower milled edge until shoulder sets against shoulder.

To properly attach an objective is not always simple, *and cannot be done too carefully.* One danger lies in the fact that the objective may be dropped onto the object, and thus injure or destroy one or the other or both, and another that the threads may be started wrong by holding the objective sideways, and the threads thus injured.

To Attach Objectives and Double Nose-Piece. *Screw each objective into proper place in the double nose-piece, with the 2-3 opposite the opening through which the light passes.*



Proper method of attaching nose-piece to microscope.

Hold the nose-piece in the right hand, objectives down. Bring the revolving screw in contact with the

screw in the tube, square with tube; with thumb and forefinger of left hand, turn milled edge of the revolving screw until it engages, swing nose-piece toward the front, and, holding it in this position, screw the ring home.

The same procedure as above holds good for attaching objectives to the triple and quadruple nose-pieces.

Finding an Object. The slide upon which the object is mounted is placed upon the front of the stage and slipped under the spring clips to a point where the object comes as nearly as possible in the center of the opening of the stage.

With low power objectives, which are used on coarse and large objects, it will be found, after properly focusing, that a portion of the object will show itself in the field, and upon moving the slide it can easily be brought to the center. In this connection it must be remembered that the image in the eyepiece is in a reversed position from that of the object, and that a movement of the object to the left is an apparent movement to the right in the field. In case of a small object which is not found after the objective is known to be in focus, as may be told if the mounting medium or small particles of dust on the cover glass are visible, move the slide about on the stage by grasping one end with the thumb and forefinger, when the object can usually be recognized by its shadowy outlines as it flits across the field. The difficulty of

finding an object or a particular spot in it becomes more difficult with the increase in power, and even in experienced hands sometimes becomes quite vexatious. Recourse may be had to two methods:

By using a low power eyepiece.

By using a low power objective as a finder.

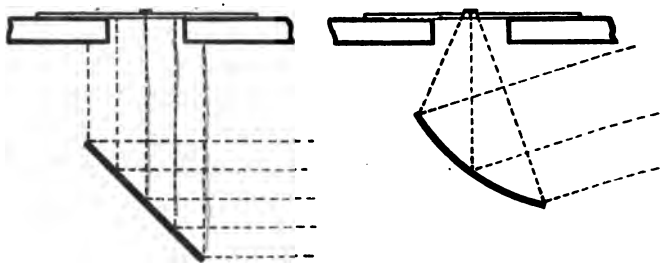
A large field is thus obtained in which the object may be more easily found, and after moving to the center of the field, the low power objective is removed and the high power attached; or in case the revolving nose-piece is used, use the low power objective as a finder, then swing the high power objective into position, care being taken not to touch the slide, and focus in the manner to be described. The object may not be in the field, due to a slight variation in the centers of the objectives, but it will certainly be very close and ought to be easily found.

To Illuminate the Object. This is an extremely important feature, and should always be carefully done, as one may easily fail to obtain the best results, may be led to wrong conclusions, or may injure the eyes. The mirrors of the microscope are usually plane and concave, and are provided with universal joint so as to be able to reflect the light from any source in front or at the side of the microscope.

The plane mirror reflects the light in the initial intensity of its source, and is used with low power

objectives. The concave mirror concentrates the rays on the object, thereby giving intensified illumination, and is used with medium and high power objectives, except when substage condenser is used, when the plane mirror only is employed.

The sources of light are either daylight or artificial light; if the former the light of a northern sky is pre-



Illuminating object with plane mirror. Illuminating object with concave mirror.

ferred, and if the latter a flat-wick oil lamp or Welsbach gas burner. An ordinary gas flame should not be used on account of the difficulty of obtaining equal illumination and the constant flickering which is very injurious. When using a flat-wick lamp the narrow edge of the flame should be used, as this is more intense than the broad side.

When using daylight place the microscope, as nearly as possible, directly before a window, and when a lamp

is employed, have it on the table either in front or at the right side of the microscope and within easy reach. Light is either *transmitted* or *reflected.* When the former, it is used to illuminate transparent objects and passes through the objects from below the stage into the objective. With opaque objects this is impossible and reflected light is required, when it is directed onto the object from above and illuminates its upper surface. In the following instructions it is assumed that transmitted light is used unless otherwise stated.

The concave mirror converges the light and its focus is of such length that with parallel rays (daylight) the light will fall on the object. With diverging rays (lamplight) the focus will be longer, and while ordinarily the mirror may remain in its position, it is advisable in critical work to properly focus the mirror by increasing its distance from the object.

Before lighting an object make certain that the mirror bar is in exactly central position, and set the mirror at such an angle to the light that it will be reflected upon the object, which can be done more quickly at the outset by observing the object or the opening of the stage, keeping the head at one side of the tube. Now remove the eyepiece, and observe the light through the objective. It should be central and of equal intensity, which with daylight is sometimes difficult to obtain as the sash of the window may be reflected and show itself in the field as dark bands, or

in the case of lamplight the blue portion of the flame may appear as a dark spot. These are only preliminary directions but will suffice for a beginning. There will be little difficulty in obtaining proper illumination at the outset if one will observe the following:

Remove the eyepiece and, looking through the back of the objective, have

Central illumination.

Even illumination over the entire field.

Mellow illumination.

Defects in illumination which may not be apparent will show when the eyepiece is replaced, and are indicated,

When dark points or shadows appear in the field.

When the outlines of an object are bright on one side and dark on the other.

When the object appears to lie in a glare of light.

In the first two cases the correction can be made by suitably adjusting the position of the mirror, in the last by reducing the amount of light by the use of a diaphragm.

It is now generally conceded that observations with the microscope may be made to any extent without any detrimental results to the eyes, provided, however, that the conditions of light are just right. It is a good rule to follow, to use as small an amount of illumination

as will comfortably show the structure which is being studied, and it may also be safely accepted that, if the eye tires or feels uncomfortable, the light should be moderated.

Illumination is either

Central or axial, when the center of the mirror is in the optical axis, or

Oblique, when the mirror is swung to one side, which in objectives of wide aperture will disclose structure that cannot be seen with central illumination.

To focus an objective is to adjust its relation to the object so that a clear image is obtained. Focusing should involve no danger to the front lens of the objective, or to the cover glass by their coming in violent contact. With the low power objectives, in which the working distance is great, there should be little danger; with the higher power objectives, in which the working distanee is so small that the front of the objective is very close to the cover glass, there is considerable.

To focus low power objectives:

Attach objective to the nosepiece. Lower the head to the level of the stage, watching the front of the objective; lower the tube by the coarse adjustment until the front of the objective is within one quarter inch of the object; look through the eyepiece and slowly elevate by the coarse adjustment until the image is distinct. Use fine adjustment.

The upward movement should be slow so that, if the object be faint, it is not missed and the adjustment not run beyond its focal distance; or it is possible that, in the case of a very minute object, it may be out of the center, and thus out of the field of vision, in which case the surface of the cover glass, or the minute particles of dust upon it should be distinguishable.

The object will first appear with faint outlines and indistinct; then gradually more distinct, and finally sharply defined, and if adjustment goes beyond this point, it will gradually become more dim, in which case return to the point of greatest distinctness.

To focus high power objectives:

Attach objective to nose-piece. Lower the head to the level of the stage and look between objective and cover-glass toward a window or a flame. Slowly lower the objective with the coarse adjustment until the front of the objective is nearly in contact with the cover glass; look into the eyepiece, slowly elevate the tube of the coarse adjustment until the image appears. Use fine adjustment.

It is also advisable while watching for the image to appear to move the object slowly in different directions, as the flitting of shadows or colors across the field will give indications that the objective is nearing the focal point.

Always focus upward. In case a low power is exchanged for a higher power objective, or when the low power has been used as a *searcher*, i. e., to find a certain object in a collection, or a certain locality in a specimen, the tube should first be elevated, as working distance in the high power is too short to admit of screwing it into the nose-piece, then detach the low power, attach the high power and proceed to focus in the order given.

Objectives which make up the regular outfits are so adjusted as to be par focal, i. e., are so fitted to the nose-piece that as either one is swung into position, it is so nearly focused as to require the use of the fine adjustment only. Very low power objectives vary so much in their focal lengths from those powers which make up the outfit that it is generally impossible to make them par focal. The 2-3 and 1-6 or 1-8 on the double nose-piece, and 2-3, 1-6 or 1-8 and the 1-12 oil immersion on the triple nose-piece are so made. But in a combination of a lower power with 2-3 and 1-6 on the triple nose-piece, or a lower power with the 2-3, 1-6 and 1-12 on a quadruple nose-piece, it is impossible to get the lower power par focal with the others.

As the adjustment of the objectives to make them par focal is quite delicate, each arm of the nose-piece is marked to correspond with the power of the objective which is to go into it. Furthermore it is highly important to *preserve proper tube length.* In the short

tubes the objectives are adjusted for exactly 160.0 mm. distance and if no revolving nose-piece is used, should be set for this length. With the revolving nose-piece the tube should be contracted so that the ring of the draw-tube rests upon the shoulder of the main tube.

To focus with double nose-piece:

Contract tube, focus with 2-3 objective, then swing nose-piece until 1-6 nears the cover glass, lower the head to the level of the stage and endeavor to slowly swing objective into place. Should the front of the objective threaten to come in contact with the cover glass, the tube must be elevated and the objective focused.

The method of procedure with triple and quadruple nose-pieces is very much the same as with the double, and the same rules will apply.

Oil Immersion Objectives. Immersion contact between the objective and cover glass is made with cedar oil. This is specially prepared so as to have the same refractive index as glass and *great care should be used to keep it free from dust.* Apply the smallest quantity to the front lens, by allowing the superfluous amount to run from the rod or brush, before objective is attached to nose-piece. If air bubbles are contained in the oil, remove it and apply a fresh quantity. This is exceedingly important, as the presence of dust or air bubbles in oil may destroy the definition of the best objective.

Attach the objective and lower it until the fluid comes in contact with the cover; observe this by lowering the head to the level of the stage. Focus as with dry objectives.

Special care must be observed if a low power objective is used after an oil immersion. The oil must invariably be removed from the top of the cover glass by wiping first with a moist cloth, and then cleaning with a dry cloth. The front of the objective should always be cleaned in the same manner immediately after it has been used.

To Focus with Fine Adjustment. After the focus has been found with the coarse adjustment, the fine adjustment should be brought into action, in order to obtain a more sensitive and reliable adjustment for focusing through the different planes or depths of the object. Its range of movement is necessarily short and at one end the screw comes to a stop, and at the other goes beyond the limit of movement and becomes inoperative. It should always be kept as near as possible *at the medium point of its range.* Grasp the milled head of the fine adjustment with the thumb and forefinger of one hand (right) and, turning the screw in either direction, focus in different planes of the object, while the other hand (left) moves the object.

Use of Substage Diaphragm. The purpose of the diaphragm is to modify the amount of light, and by its aid obtain results in definition of the object which without it are impossible. Much will depend upon the density of the object, the intensity of illumination and the power of the objective.

Use an opening in the diaphragm of about the same size as the front lens of the objective.

As a rule this will be found to give a superabundance of light, especially in low power objectives, and by reducing the aperture it will be found that there will be an increased differentiation in the object. The diaphragm should be reduced to a point where the amount of illumination will be perfectly comfortable to the eye.

Do not use so large an opening that there will be an uncomfortable glare, nor so small that undue exertion is required to see structure.

When oblique light is used, there should be no obstruction to the course of light, and with the iris and revolving diaphragms full opening should be employed.

Which Eye to Use. The right eye is generally used for observations, but, while the manipulator may from habit be inclined to use this, it may be possible that in some cases the left can be used to best advantage and with less fatigue.

Make it a habit at the outset to keep both eyes open.

There is a point over the lens called the *eye-point* at which the rays cross within the smallest compass, and *this is the proper position for the eye.*

When above or below this point the size of field will be reduced or shadows or colors will appear in it. In low power eyepieces the eye-point is some distance from the lens, in high power quite close to it,—in fact, in some, so close that the eyelashes rest upon the lens and sometimes appear in the field as dark bars.

Cover Glass and Spherical Correction. The cover glass has a pronounced influence on the spherical correction of objectives. A variation in thickness from that used by the makers of objectives, while not appreciable in low powers, such as 2-3, may be very detrimental to satisfactory definition with a 1-6 or a 1-8. Unfortunately, this effect is not generally known, or if so, not sufficiently appreciated. A variation of 0.05 mm. either thicker or thinner than the standard thickness is sufficient to totally obliterate the fine structure in an object, leaving the coarse lines only apparent, and a slighter variation affects the image proportionately. There is no one thickness adopted by the different makers and some even allow themselves considerable latitude in adjusting their objectives, so that there is a noticeably varying result with different objectives on the same specimen.

Then, too, one great difficulty lies in the fact that it is commercially impossible to produce covers of one thickness. They are made in three numbers of the following thicknesses:

No. 1. 1-150 to 1-200 inch or 0.16 to 0.13 mm.
No. 2. 1-100 to 1-150 inch or 0.25 to 0.16 mm.
No. 3. 1-50 to 1-100 inch or 0.50 to 0.25 mm.

The No. 2 cover glasses are in most general use, 0.18 mm. thickness being best suited to objectives as now corrected. A good plan is to procure a cover glass gauge and measure the covers.

Set aside those from 0.17 to 0.19 mm. thick for use on specimens with which 1-6 or 1-8 inch objectives will be used. Those thicker may be laid aside for use with 2-3 and lower powers, and the thinner ones for oil immersion objective.

Under these conditions it is important to suggest methods by which the utmost efficiency of an objective may be obtained.

To judge spherical correction by use of histological or biological objects and on Bacteria and Micrococci with oil immersion objectives, without a previous knowledge acquired from objects which are more suited, is extremely difficult, but a study in this direction will be found exceedingly valuable in utilizing the full capacity of the objectives.

To judge spherical correction with a 1-6 or 1-8, the diatom *Pleurosigma angulatum* is best suited to a preliminary study. Select a diatom which is flat and locate in the center of the field. Focus carefully so that the margin of the object will be sharply defined and observe the markings. If they should show in the same plane without any further focusing, the spherical correction may be accepted as being correct.

If the lines appear to lie in a higher plane, and it is necessary to focus upward, so that the margin of the diatom is out of focus, it indicates spherical over-correction and the remedy is found in the contraction of the tube length.

This should be done progressively in spaces of about one-half inch, and after each change carefully focus again until proper correction is obtained.

When the lines appear to lie below the plane of the object, it indicates spherical under-correction, and can be corrected by increasing the tube length.

If there are two or more eyepieces, results can be obtained quicker with the higher powers. If the markings cannot be seen it may be due to abnormally thick or thin covers, a not uncommon occurrence, thus destroying the resolving power. This may be judged by using slightly oblique illumination. If too much is used the nice differences will be lost. If from a preconceived idea of what any other object should show

it is hazy where one expects it to be distinct, or if it fails to show detail which is known to exist, and being certain that the objective and eyepiece are properly cleaned, it may generally be ascribed to lack of proper correction. By focusing either above or below the proper focal plane, there will be an enlargement of the outlines of the object or a *coma*, which gradually enlarges as the objective recedes from the proper focal point.

If the expansion or coma is greatest when the objective is elevated, there is spherical over-correction, and the tube length should be decreased.

Should the expansion be greatest when the objective is lowered, there is spherical under-correction and the tube length should be increased.

ILLUMINATION WITH SUBSTAGE CONDENSER.

Purpose of the Condenser. The purpose of the condenser is to give an amply illuminated field when the illumination is otherwise insufficient, and to illuminate the object with a cone of light having an angular aperture equal to that of the objective, as well as to provide means for controlling the amount and character of the illumination to suit the various conditions of work.

Abbe Condenser 1.20 N. A.

Abbe Condenser 1.42 N. A.

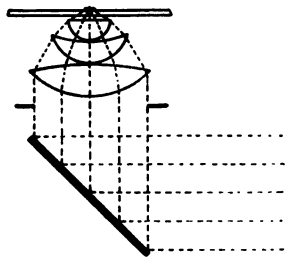
The Abbe condenser of 1.20 N. A. is in most common use and the most simple form of mounting is one which has attached to its lower side an iris diaphragm for regulating the amount and angle of light and a vertical screw motion.

The most complete form has adjustments for obtaining every modification of illumination, with rack and pinion for vertical and lateral adjustment.

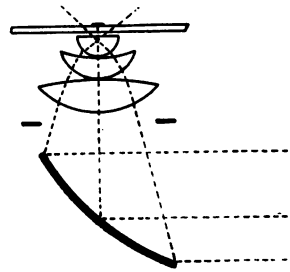
The condenser should not be used on very low power objectives as it is distinctly harmful and the mirror alone provides ample illumination.

Use only plane mirror with the condenser.

A condenser is so constructed that parallel rays of light are brought to a focus above the upper surface of its uppermost lens and in the plane of the object, If the concave mirror is used the convergence of light is more rapid and the apex of the cone of light is within the condenser and its effectiveness depreciated.



Illuminating object with condenser and plane mirror. The right way.



Illuminating object with condenser and concave mirror. The wrong way.

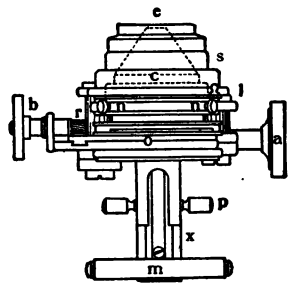
Centering the Condenser is the act of bringing its optical axis coincident with the optical axis of objective.

To verify correct centering two easy methods may be followed:

I. Use a 2-inch objective and focus through the condenser onto the diaphragm, which is reduced to its smallest opening.

II. Use a 2-3 or 1 inch objective; focus upon upper surface of condenser or upon an object which should then be removed; elevate objective with coarse adjustment until a dimly defined dark spot appears in the field and with proper focusing is about 1-3 of the diameter of the field.

Centering of the condenser does not imply that the cone of illumination is also centered and it is fully as important to secure the correct conditions in one as it is in the other.



Complete Substage. Front View.

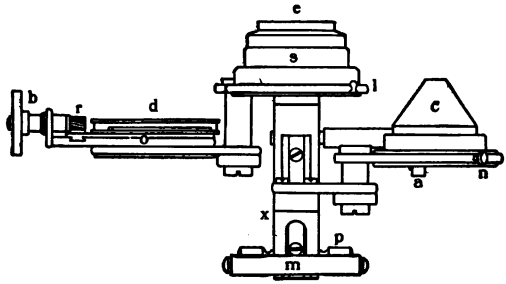
Centering the Illumination. The mirror may be so adjusted that the light will be directed toward the periphery of the condenser and when lamplight is used the light may be so placed as to give all gradations of oblique illumination from the central to the limit of aperture, although the condenser may be centered.

With daylight have evenly illuminated field.

With lamplight attach 2-3 inch objective; open diaphragm to full extent and focus upon the minute image of flame; adjust mirror so that the image will be in the center of the field.

To Focus Condenser. In all the various forms of mountings the condenser is so mounted that at the uppermost limit of adjustment its upper surface is just below the surface of the stage so that it cannot come in contact with the slide.

With all objectives having a numerical aperture less than 1.0 the condenser may be used dry, i. e., without oil.



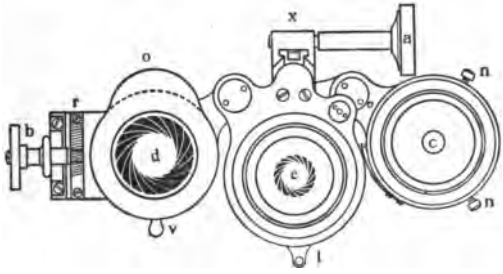
Complete Substage. Front view, with condenser and lower iris diaphragm swung out of optical axis.

In the use of the condenser with oil immersion objectives the custom prevails of using the condenser dry. It is well to point out, however, that both the condenser and the objective lose in their efficiency when the former is used dry, and for critical work the condenser should be in immersion contact with the slide.

To make immersion contact between condenser and slide place a drop of oil on the top of condenser, drop the slide upon the stage, first throwing the clips to one side.

With immersion objectives the proper focusing of the condenser becomes a matter of nice distinction to obtain best results and can only be reliably accomplished by considerable practice and experience. To obtain best position :

Use a 2-3 objective; focus upon the object; adjust condenser until image of window-sash or flame is in the same plane with the object.



Complete Substage. Top view, with condenser and lower iris diaphragm swung out of optical axis.

Relation of Aperture of Condenser to Objective. In the study of Bacteria and other micro-organisms, the objectives used being of wide aperture, it is sought to have them stand out boldly in a bright field. This is accomplished by bringing the diaphragm to its full aperture. On all other objects, however, too much illumination decidedly injures definition by obliterating detail.

Little experience is required to judge when the condenser has its proper opening. When correct, the image will stand out sharply defined without any appearance of fogginess and as the diaphragm aperture is reduced it will be noticeable by the decrease in the amount of light. By removing the eyepiece and looking at the back of the objective the relative aperture of the condenser to that of the objective may be easily seen, as the outlines of the diaphragm are sharply defined. In testing for this start with the smallest aperture of the diaphragm and gradually increase its diameter. If the opening in the diaphragm appears to have the same opening as the back of the objective, the condenser has the same angular aperture. In the following instructions for the proper use of light from the condenser the size of opening of its diaphragm as it appears by viewing the back of the objective is called *apparent aperture.* By experience the following conditions have been found to give most satisfactory results:

In oil immersion objectives on bacteria use the full opening of diaphragm.

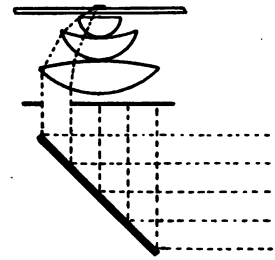
On diatoms reduce the apparent aperture to about two-thirds opening in objective.

In histological and other dense objects use the apparent aperture equal to about one-half the opening of back lens in objective.

In dry objectives the aperture of the condenser should always be less than that of the objective.

Oblique Light with Condenser. Oblique light may be obtained by setting the mirror alone in such a position that the light reflected from it shall enter the condenser only at one side, leaving the balance of it unused. This, however, is only advisable when the condenser mounting has no other provision for obtaining oblique light. In the mountings having such provision oblique illumination may be obtained by two methods:

I. Focus objective; reduce the apparent aperture to that of the rear lens of the objective, swing the plate o, page 23, carrying the lateral adjustment around so that the pinion button is at the front. Turn the pinion button so that the opening will move from the center to the periphery of the condenser.



Illuminating object by oblique light with condenser.

II. Proceed as above with this difference. Remove eyepiece and view the bright circle of light as it passes from the center to the periphery of the rear lens.

When the circle of light has passed beyond the limit of aperture of the objective the field will become dark.

In objects with striated structure, the illuminating rays should be brought to a position at right angles to

the striae, either by rotating the object to the proper position, or by swinging the diaphragm plate.

In using process II the circle of light should be bright. As it nears the edge, colors become apparent until finally at the edge of the objective the violet and red are quite pronounced. With proper disposition of the mirror the colors may be so equalized that after a little practice the illumination will be found at its best after the eyepiece is applied.

With either method lamplight will be found to give best results, but care must be taken that, as the diaphragm passes toward the oblique point, the mirror is also adjusted so that the illumination will not be lost.

In the Abbe condenser the chromatic aberration is quite apparent with extreme oblique illumination. The field ceases to be equally illuminated and all the colors of the spectrum from the violet to the red are plainly evident within the field of view. Under these conditions it is of course impossible to view large specimens without slightly shifting the mirror so as to move the lightest portions of the spectrum to different parts of the field. With small specimens the mirror should be so directed that the light or yellow portion of the spectrum is in the middle of the field.

CARE OF A MICROSCOPE.

Besides acquiring the ability to properly use an instrument with its accessories, it is important to know how to keep it in the best working condition. It may be said without reserve that an instrument properly made at the outset and judiciously used should hardly show any signs of wear either in appearance or in its working parts, even after the most protracted use; and further than this, every good instrument should have a provision for taking up lost motion, if there is a likelihood that this may occur in any of the parts.

Especial care should be given to the optical parts, in fact such care that they will remain in as good condition as when first received, after any amount of use. Accidental injury may occur, but is quite unlikely if a systematic manner of working is followed, if a special receptacle for each part is provided.

Do not allow any person except your teacher to manipulate your microscope or accessories. One person may be expert in the manipulation of one instrument and still find it difficult to work with another. The fine adjustment particularly causes the

greatest difficulty, as in some instruments the movement of the fine adjustment is in a direction opposite to that of the micrometer screw, and thus the objective as well as the object is endangered.

If the microscope is to be carried any distance it should be done in its case.

Avoid exposure of the microscope to direct sunlight and extreme or sudden changes in temperature. If by chance the microscope should have become very cold, as during transportation in winter, allow it to warm gradually.

Care of the Stand. *Keep free from dust is one of the first rules to be observed.* When not in use place the microscope in its case or cover with a bell jar or close mesh cloth such as cotton flannel or velvet which should reach to the table. If the case will not receive the entire outfit, remove the double or triple nose-piece, if these form part of it, and place objectives in their cases If dust settles on any part of the instrument remove it first with a camel's hair brush and then wipe carefully with a chamois skin, wiping with the grain of the finish of the metal and not across it, as in the latter case it is likely to cause scratches.

When handling the stand, grasp it by the pillar or stage. While the arm is the most convenient part it is at the same time the most dangerous to the fine adjustment.

Avoid sudden jars, such as placing upon the table or into the case with force.

Remove any Canada balsam or cedar oil which may adhere to any part of the stand with a cloth moistened with benzole and wipe dry with chamois.

Use no alcohol on any part of the instrument as it will remove the lacquer. As the latter is for the purpose of preventing oxydization of the metals, it is important to observe this rule.

To use the draw-tube impart the spiral motion.

To lubricate any of the parts, use a slight quantity of soft tallow or good clock oil, or paraffine oil.

If the pinion works loose from the jar incident to transportation or long use, which sometimes occurs to such an extent that the body will not remain in position, increase its tension by tightening the screws on pinion cover.

Occasionally withdraw the tube from the arm, wipe clean and lubricate both slides. This is highly important as the slides being constantly exposed become dusty and the lubricant is inclined to gum.

Apply a small quantity of soft tallow or good clock or paraffine oil to a cloth, wipe well over the surfaces and remove the superfluous amount with a dry cloth or Japanese paper. If the lubricant becomes gummy, remove by wiping with a small quantity of benzine or benzole applied to cambric.

Do not apply oil or grease to the rack or pinion as this will act as a dirt catcher and wear out the teeth at the points of contact.

In inclining the stand always grasp it by the arm and never by the tube, as in the latter case it may loosen the slide or tear off some of the parts.

In using a screw driver grind its two large surfaces so that they are parallel and not wedge-shaped, so it will exactly fit in the slot of the screw-head. Turn the screw with a slow steady motion pressing the screw-driver firmly into the slot. No screw-head will ever be injured if these points are observed.

When repairs or alterations are necessary, always have these made by the manufacturers who can, from a system of duplicated parts, do it not only cheapest, but best.

Joint for Inclination. If the joint should become loose so as to prevent the arm being set at any angle of inclination, it should be tightened by drawing up the nut at one or the other side. If the nut has screw slot use a properly prepared screw driver, but if two holes a suitable key should be obtained from the maker. In high grade instruments the axle is generally tapering, and to determine which nut is to be drawn up can only be done by trial.

Care of the Coarse Adjustment. Special care should be given to keep the coarse adjustment free from dust as its effect is particularly pernicious. The slides and rack and pinion are necessarily exposed and the lubricant is apt to catch dust and also to gum. The tube should be occasionally withdrawn from the arm and the slides carefully wiped with a cloth moistened with benzole. Lubricate by applying a small quantity of soft tallow or paraffine oil to a cloth and wiping well over the surfaces, removing the superfluous amount with a dry cloth. The teeth of neither rack nor pinion should ever be lubricated. An occasional cleaning of the teeth with an old tooth brush is advisable.

It is advisable occasionally to lubricate the pinion shank on both sides of the arm with a very minute quantity of paraffine oil.

If the pinion works loose from jar incident to transportation or long use, which sometimes occurs to such an extent that the body will not remain in position, increase the friction upon it by tightening the screws on the pinion cover.

Fine Adjustment. In a general way it may be said that if the fine adjustment ceases to work satisfactorily the instrument had better be returned to the maker, as it involves the most delicate working and few people are conversant with its construction. There

is very seldom any occasion for this, however, if used with reasonable care.

If the fine adjustment does not respond to the turning of the micrometer screw, or if it comes to a stop, it indicates that the adjustment screw has come to the limit of its motion at either end. It should by no means be forced; it should at all times be kept at a medium point.

The micrometer screw should never be removed unless after long use it works with a pronounced gritty feeling. In this case unscrew from its bearing, wipe clean with a cloth moistened with benzole, and after wiping dry apply good tallow, being careful to start the threads properly. If they are not properly started much mischief may be done. In some instruments the threads are left handed. In removing the screw observe whether there is a small steel pin in a recess in it, and if so be careful that this is in proper position when returned or else the fine adjustment will be inoperative.

Screw-Driver. Ordinary screw-drivers are not fit for use on the microscope. A properly made screw-driver should be ground on its two large surfaces so that they are parallel and not wedge shaped, so that it will exactly fit in the slot of the screw head. In using, turn the screw with a slow, steady motion, pressing the screw-driver slowly into the slot. No screw head will ever be injured or marred if these points are observed.

DO NOT REMOVE
OR
MUTILATE CARD